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Reconfigurable Multiple Sensing node for the Automation of Agricultural Field

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***Abstract:** In a real time system, monitoring and control of various parameters of the field is vital .In order to achieve high yields and quality , exact parameters of soils and its necessary inputs to soil need to be put in action. Pest and diseases are also important factors in decline of yield and quality. Considering the various applications of this area, the present paper explains the wireless multi-sensing node for remote monitoring and control system for agricultural applications. This is design with a number of good performance front-end devices and circuits suitable for various types of sensors. Any Sensor device elements can be directly connected without the need of extra circuits. The number of input sensors can be reconfigured with time to time as system demand. The paper describes development and the interface of high performance and low-cost typical features elements. The developed system displayed all the measures field parameters and corresponding set point values on the LCD interface and also are stored in external interface memory for future reference. The developed node can be connected to a personal computing system for decision support using wired RS-232 interface or wireless connectivity using the RF modem from Xbee.*

***Index Terms:** Multiple sensors, Automation, Xbee Wireless module, Real time remote monitoring*

I. INTRODUCTION

Considering the several applications of this area the present paper describe the Reconfigurable multiple sensing node for the automation of agricultural field. Interfacing sensors with a microcontroller unit can add up sensors performance such as self calibration, self detection, and converting the raw sensor data into a usable digital form. The developed wireless sensor node is microcontroller based embedded system specially designed to detect and compute the values of the physical parameters from sensors in engineering units. It comprises microcontroller unit, multiple sensors, signal conditioning circuit, data acquisition system, digital display and power supply section. Moreover, the RF module Zigbee is employed to facilitate wireless communication [1,3].

With accordance to the physical parameters, generally Sensors work on variation of certain electrical parameter such as current, voltage, resistance, capacitance etc. The operating ranges, magnitude of change and the characteristics differs from sensor to sensor [5]. This phenomenon demand to have an interface circuit, which is giving a fixed range of electrical output either voltage or current from the input sensors. The commercially available smart sensor cards allow connection of only 3-4 limited numbers of inputs for sensors [4]. In this system, a maximum of eight sensors can be connected at a time or can increase if needed. In this the embedded microcontroller detects sensors and select the ranges, sets gain, select analog signal conditioning unit, etc. The developed system provides the facility of interface of Capacitive Sensor, LVDTs, Thermocouples, Fiber Optic Displacement Sensor, Thermocouples, Strain gauges, RTDs and Thermistors sensor etc. The development and implementation of multiple sensing node module is discussed and presented in this paper.

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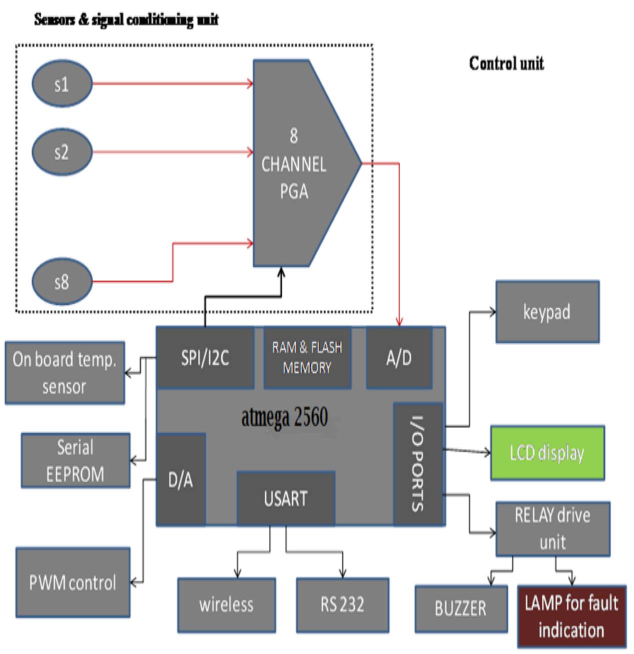
II. SYSTEM DESCRIPTION

The Implemented module has eight inputs connection points for eight different sensors. Each sensor has dedicated signal conditioning unit. No further signal conditioning is required externally .All necessary signals conditioning, excitations, and linearization are embedded on the developed module. The output signal of the sensors is first conditioned by signal conditioning unit for ease to access. The analog data output from the signal conditioning units were converted to digital data form for further processing, display, and transmission and storage. Types and approaches of signal conditioning depend upon the kinds and characteristics of the sensor used. The architecture of the developed system is shown in figure.1 and is divided into two sections, a sensor specific signal conditioning and control or execution unit.

In this system each sensor unit is associated with a specific conditioning circuit. For initial set-up of the system, two push button switches are provided for users interface. At the starting, user must select the type of channel or sensor and the measurement ranges of the channel by setting the switch provided. The same system can be used for other types and ranges of sensors with different configurations. For eight sensors input there are eight different conditioning circuits. The control unit consists of a microcontroller with ADC, programmable gain amplifier (MCP6S28) and a power supply. The developed system is design using 8 bit microcontroller, atmega2560 which has 10 bits ADC with acquisition time 12.86µs, 256k bytes of flash, 4 Kbytes of data and supports four programmable serial USART. Programmable gain amplifier (MCP6S28) gives the designer program control over an amplifier of the sensing section and can interface serially with controller using SPI bus.



For testing the developed system, an eight potentiometer circuit has design in replica to eight sensors and is connected at the eight input of the Programmable gain amplifier (PGA). Using the switches provided and following the instruction display on the LCD screen set the gain of Programmable gain amplifier accordingly. The d.c 0-5Voutput of PGA is converted into digital form by the ADC. For the setting of the system two push button switches are provided. The stored set point from the internal memory of the microcontroller (flash) can be select using switch for each input parameters. The set value can be changed by using switches according to need. The program compares set values and sensing values than make alarm sound if sensing value > set point.

Set points values can be adjusted later if needed through switches provided on the module by the user.

Similarly, for all the inputs, using corresponding switch set point value can be set for respective sensors inputs. Alarm circuit is excited through an open collector source transistor array (ULN2003). For the transmission to remote personal computer or decision support unit, the microcontroller continuously checks if character '#' has been received from remote system unit, if received then it transmits all measures parameters and corresponding sensors set point values to the hyper terminal as shown in Fig.2 and continue execution of the main program.

Sensing data are stored in flash memory of the atmega2560 microcontroller and as well as on the serial EEPROM via I2C bus interface. The wired module RS232 or unpaid wireless module Xbee transceiver, which has data transmitting capacity up to 1.6 km at 2.4G.Hz are used to transmit the measure parameter values and their set - point values and as well as to LCD unit simultaneously.

The developed system has an interrupt facility to generate an interrupt on detection of a battery power backup fail/low condition and initiates an alarm sound. Programming of the module is done using high level language to save time along with Keil micro vision which is free of cost from Atmel.

III. SOFTWARE FLOW OF THE SYSTEM

A. Sensing Unit

In this module, the microcontroller interface six analog input through SPI based programmable gain amplifier (PGA). The programming flow is as shown in fig.3. To select the channel and gain of the sensors, first configure SPI communication bus by configuring MSSP control registers, SSPCON1 and SSPSTAT. After SPI initialization through key control we initialized gain and channel.

Fig.2: Eight potentiometers setup and Hyper-terminal Transmission

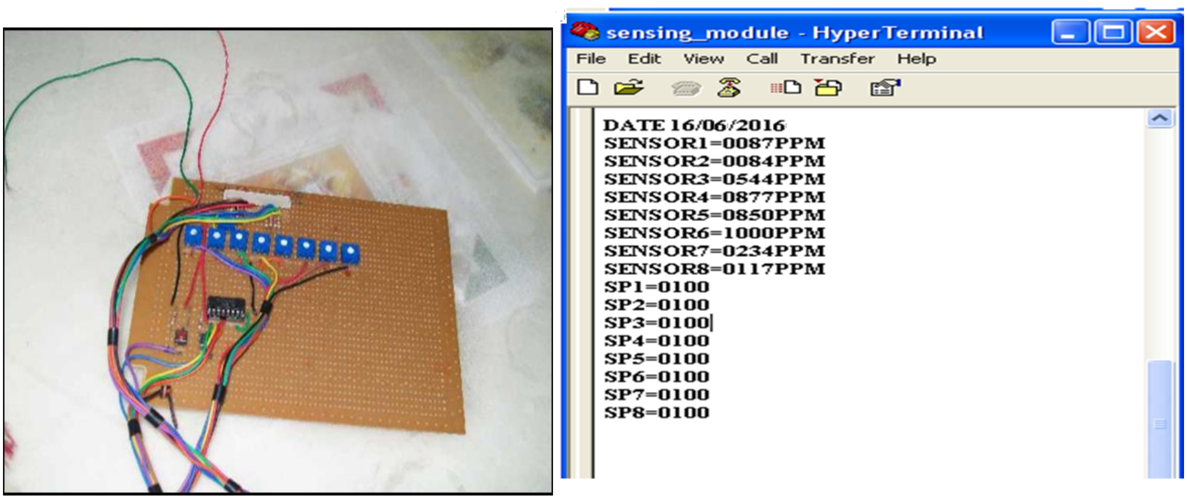


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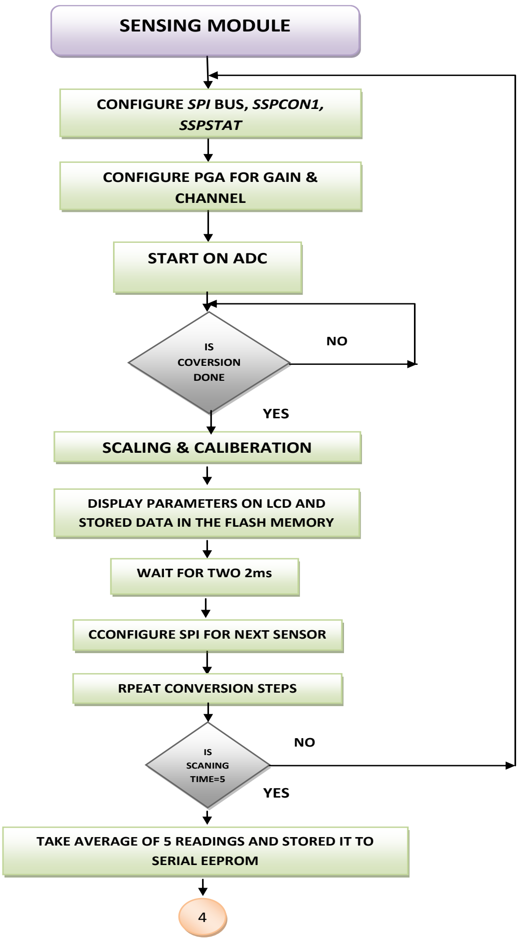
Fig.3: Program flow of sensing unit



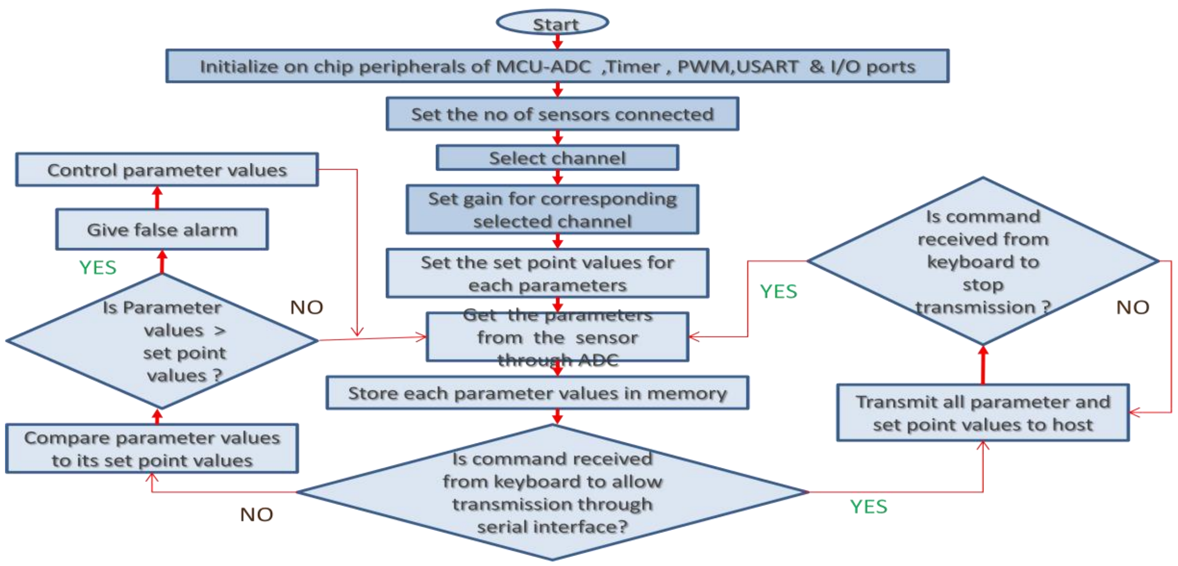
parameters and wait for transmission to the serial EEPROM. This scanning rate and writing data to the serial EEPROM can be change through programming as needed. Parameter value can be adjusted as needed. Similarly, set point values can be set for remaining channels parameters. If another parameter has to be set among eight parameters, the processor can switch to another parameter among eight parameters periodically in similar manner by pressing selected switch. Alarm circuit is excited by an open collector source transistor array (ULN2003). In between all process, the microcontroller continuously checks if character '#' has been received from remote system unit, if received then it transmits all measures parameters and corresponding sensors set point values to the hyper terminal screen. The non-volatile memory, On-chip flash and also EEPROM have been interfaced via I2C for storing all the measured data. All values both measured and set points are transmitted to LCD unit using the LCD interface and also can be transmit serially via wired or wireless module. The main advantage of the system is that it can control or select the gain through program which can be set by the user for each channel. This is achieved because of the PGA. The system software flow diagram is as shown in fig.4.

The system compares the set point values and corresponding sensors values if exceed a false alarm is initialized and wait for control actions.

B. Overall System

In the developed system, at the starting, the user can set the number of sensors connected with their respective channel number and set points using the switch provided and following the command display on the LCD. The control of the system can be performed by two switches connected on

Fig.4: System work Flow



Then start on ADC for conversion process. After conversion the scaling and calibrations are perform and convert BCD to ASCI for LCD display. ADC since SPI is much faster than ADC conversion time, after scanning of first sensor it wait for 1ms delay to avoid the conversion delays between the sensors. Each scan sensor parameters are store in the flash memory. After 5 times scan take average of the

port C of Microcontroller. The set point value can be increment or decrement by pressing one of the switches as per user's requirement.

If a switch is pressed, it escapes from set point routine and automatically compares set point and measured parameter value. An alarm indication is given if sensor parameter value is greater than set point; consequently

On further development, an actuator module can be design and implemented for controlling all the required physical parameters, for example solenoid valves, pumps etc. on the developed system. In this all the actuation will be done by each corresponding relay drive unit through programmed microcontroller.

This reconfigurable multiple sensing node, being developed using an unpaid software platform reduces cost and also size and complexity as it uses an embedded microcontroller system.

IV. TESTING PROCEDURE AND OBSERVATIONS

While testing the specific signal conditioning section, initially, only one module of one type and range was independently tested by applying the theoretical calculated inputs. The testing procedure for RTD sensor is given in following sections as an illustration.

The resistance of Pt-100, for a=0.00385, at 0°C and 100°C is 102 and 119 ohm respectively. The signal-conditioning circuit for Pt 100 was tested for 0-50°C range. Using a resistance box of a fixed resistance 102 ohm was connected at the selected position of sensor input, and was adjusted to deliver output of 4mA. The fixed resistor of 102 ohm was then replaced by 119 ohm, adjusted using potentiometer of 470 ohm and was adjusted to get output of 20mA.

Table 1: Measured Temp. Vs Chart Value

Set Resistance value (in Ohms)	*Value from Chart (Degree Centrigrade)*	*Measured value Temperature (Degree Centrigrade)*
102	5	5.1
103	10	10.12
105	15	15.00
107	20	20.1
109	25	25.1
111	30	30.1
113	35	35.03
115	40	40.2
117	45	45.1
119	50	50.12

The simulated resistance at the input was varied by using potentiometer and corresponding outputs were noted down. For remaining types of RTDs we have to select the resistor values using corresponding calibration circuit. It was observed that the output of the module varies from 4-20mA as input simulated resistance changes from for resistance 102 to 119 ohms of the simulated input, and found the change as linear. After connecting sensor, to get a fixed range of output 0-5V, the gain of programmable gain amplifier was set. This output was applied to Voltage to current converter (XTR-103) to provide a current 4-20 mA. The same output was also applied to Analog to digital converter pin whose digital output changes from 000H to FFFH. For the same system the simulated inputs were applied for all remaining types and ranges. And every time the gain of programmable gain amplifier was set to provide same output range of 0-5V. This procedure was repeated for all eight channels.

The microcontroller software was then stored in the internal EPROM of microcontroller 2560. After testing complete developed system, when a particular sensor module was plugged in the sensing unit it was observed that as the simulated input changes over a selected measurement range, the instrument provides all the outputs simultaneously. It is observed that the measured temperatures are very close to the expected temperature values from the standard RTD resistance versus temperature chart as shown below in table 1 and Fig.5.

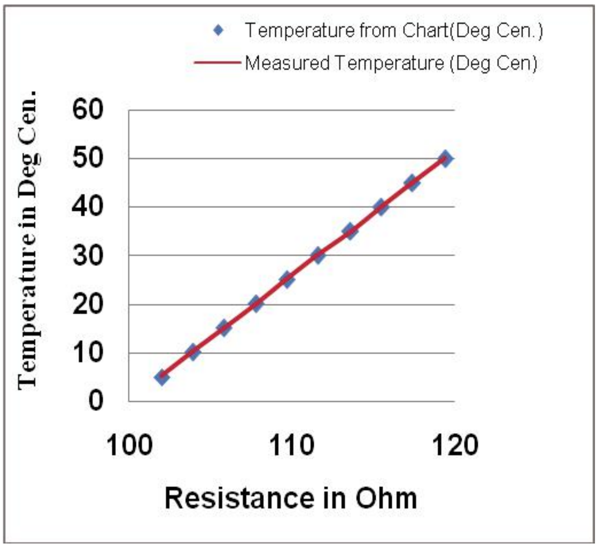


Fig.5: Temperature measurement graph

V. RESULTS AND DISCUSSION

For practical efficacy of any sensor it is important to give its performance according to the need of the application. The present system provides interface for 8 different sensors. The device is programmed using KEIL IDE programmer. Present paper particularly deals with the design and development of a multipurpose instrument that reduces the burden of the system designer. The developed module is interfaced with temperature sensors through transmitters giving 4 to 20 mA current outputs. The wireless module is interface through wired RS232 interface later can be change to USB interface. The microcontroller controls the overall process execution of the system intelligently. The provided output of the system can be use depending upon the required need. If application demands to use the sensor, whose interface is not provided in this system, then user has to only add a signal-conditioning for that sensor. For wireless coverage only the required serial wireless module need to be interface.

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Using faster processing controller the system performance can improve then present system, as it is slow in acquiring number of samples per second.

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